ENVIRONMENTAL AND AGRONOMIC FACTORS AFFECTING SEED PRODUCTION IN ANNUAL MEDICS

by

FRANCIS JACOB NAMASAKE MUYEKHO
B.Sc. (Hons.)
(University of Nairobi)

Thesis submitted for the degree of Doctor of Philosophy

in

The University of Adelaide
(Faculty of Agricultural and Natural Resource Sciences)

Department of Plant Science
Waite Agricultural Research Institute

April 1993

TABLE OF CONTENTS

ABSTRACT

Annual medics (*Medicago* spp.) are important pasture plants in the ley farming systems of southern Australia and other Mediterranean-type environments of the world. High seed production is necessary for the regeneration of dense pastures and to maximise profit on commercial seed farms. In many annual medic cultivars, as in other forage legumes, the potential seed yield (defined as the number of flowers per unit area) is high, but commercial yields are much lower than expected. Mean seed yields of rainfed medic in South Australia for example, range from 50 to 600 kg/ha both within and between seasons (Australia Bureau of Statistics 1979-89) although individual farmers occasionally have achieved yields exceeding 1200 kg/ha. The agronomic and physiological factors responsible for the large difference between potential and actual seed yield, and the large variation within and between seasons and between cultivars, have not been adequately studied. The studies reported in this thesis sought to define some of the constraints to seed production and to suggest management strategies to improve the yield of annual medic. Six field experiments and one glasshouse experiment were carried out.

To identify the constraints to seed yield within a cultivar, the relationship between vegetative growth and seed yield was examined in the field. The experiment involved two sowing dates (27 May and 27 June), five sowing rates (1, 5, 25, 125, 625 kg/ha) and two cultivars of *Medicago truncatula* (Parabinga=early-flowering, Paraggio=late-flowering). Seed yields were highest with early sowing and at sowing rates of 5 or 25 kg/ha and were related to the number of pods per m^2 at maturity. Delayed sowing reduced seed yield through a reduction in the number of flowers produced in the early part of the season and a shorter period for seed growth. The highest sowing rates produced the highest number of flowers/m^2 but seed yield at 125 and 625 kg/ha was significantly reduced by poor percentage pod set because of the occurrence of complete self-shading (LAI above 4) prior to the start of flowering. At sowing rates of 5 and 25 kg/ha, complete self-shading occurred at different times after the start of flowering but pod set was similar for both sowing rates. It was postulated that methods for improving seed yield in annual medics should be based on strategies which encourage early flower

production and which improve pod retention by increasing light penetration into the sward during the early flowering period.

In order to test the hypothesis that poor light penetration through the sward during the early flowering period was responsible for low seed yields, two shading experiments were conducted on swards of annual medics sown at 20 kg/ha. Undefoliated swards of *M. scutellata* cv. Sava and *M. truncatula* cv. Paraggio were given 30% shading at different stages of growth in 1989, and in 1990 swards of Paraggio barrel medic, defoliated at the start of flowering or undefoliated throughout the growing season, were given 30% or 60% shading at various times during flowering. In 1989, 30% shading did not significantly reduce seed yield in either species. In 1990, 60% shading throughout the flowering period reduced seed yield by a half, whereas shading in the first half of flowering reduced yields by a quarter in both the defoliated and undefoliated swards. No significant reduction in seed yield was found after 60% shading up to the start of flowering or by shading in the second half of flowering. Reductions in medic seed yield with shading were due to a low proportion of flowers that formed mature pods. The hypothesis that increased light penetration during the early flowering period increased seed yield through improved pod set was confirmed because the reduction below the potential yield was greater following 60% shading during early flowering than after 30% shading or unshaded control or when shading occurred during other stages of reproductive growth.

From the above experiments it was concluded that early flower production, a long reproductive period and better light penetration through the sward during the early flowering period are important for high seed production in annual medics. The length of the reproductive period within a cultivar depends much on the opening rains and the end of rains in spring both of which are beyond farmers' control. Low light transmission before the start of flowering in many commercial seed crops is common. Commercial seed producers use a low sowing rate (c. 10 kg/ha), graze the swards or use low rates of herbicides to restrict vegetative growth prior to the start of flowering, but published studies do not show that mechanical defoliation or grazing can increase seed yield in

annual medics. In order to gain a better understanding of the influence of defoliation on seed yield, two experiments involving different levels of severity, frequency and timing of defoliation were carried out in a lower-rainfall area (Korunye, mean rainfall 360 mm p.a.), and higher-rainfall area (Waite Institute, mean rainfall 620 mm p.a.).

The herbage production (DM) and number of flowers per m^2 at the Waite Institute was 2 to 3 times greater than at Korunye, but the highest seed yields at each site were similar (863 kg/ha for Waite Institute and 936 kg/ha for Korunye). The higher DM at the Waite Institute was due to more growing season rainfall (586 mm) than at Korunye (274 mm), but the low rainfall (7.6 mm) during the middle of the flowering period (October) at the Waite Institute, in comparison to 20 mm at Korunye, reduced seed yield through poor pod set (2 to 3 times lower than at Korunye). In the lower-rainfall area grazing in July only, i.e. before the start of flowering, resulted in greater seed yields than grazing in July plus severe defoliation at the start of flowering. Seed yield was related to the number of pods/m^2 and DM production. In the higher-rainfall area, however, severe defoliations up to the start of flowering increased seed yields. The numbers of pods/m^2 were not significantly different from the undefoliated control, but the number of seeds per pod and mean seed weight increased thereby contributing to significant increases in seed yield. Percentage pod set was not always related to seed yield. The results highlight the importance of severity and time of final defoliation in relation to season or site, whereby in a lower-rainfall area where DM production was low, defoliation at the start of flowering reduced seed yield, but in a higher-rainfall area where DM production was high, severe defoliations up to the start of flowering increased seed yield. The study also showed that the components that most determine seed yield will vary with site, season and management. At the Waite Institute, low rainfall during October resulted in severe moisture stress during the middle of the flowering period. Defoliation reduced plant water stress and increased seed yield by increasing mean seed weight and number of seeds per pod. In contrast, at Korunye seed yield was limited by the small number of flowers per m^2 but high pod set increased seed yield.

The response of seed yield to defoliation at early flowering under different moisture regimes was tested in a glasshouse experiment. Both water stress and defoliation reduced seed yield but there was no Defoliation x Moisture stress interaction. Reductions in seed yield as a result of defoliation 3 weeks after start of flowering were smaller than those caused by water stress. The reduction in seed yield with water stress was due to fewer pods per m^2 as a result of reduced flowers per m^2 and lower percentage pod set. However, with defoliation, improved percentage pod set partly compensated for the fewer flowers per m^2 and, as a result, yields were better than those caused by water stress. The study, however, failed to show that the level of plant water stress was reduced by defoliation: this result was in contrast to the field studies.

To test if the potential benefit of defoliation prior to flowering is generally applicable to a wide range of cultivars, a field experiment involving 10 cultivars was carried out at the Waite Institute. Cultivars were chosen which differed in maturity, ability to produce flowers, number of seeds per pod and mean seed weight. The reasons for choosing these cultivars were also to find out the extent to which seed yield is limited by the number of flowers/m^2 and percentage pod set. The extent to which percentage pod set is limited by time to first flower or the potential sink size (potential sink size=number of flowers per raceme x mean pod weight (Cocks 1990a,b) at each flowering node and the improvements that could be obtained by defoliation were also investigated.

Seed yields differed significantly between cultivars but not between defoliation treatments (defoliation at a height of 3 cm or 6 cm up to the start of flowering or undefoliated), indicating that yields may be little affected by defoliation in most medic cultivars if it ceases at an early stage of growth. The most important factor contributing to high seed yields was setting a large number of pods/m^2 (r=+0.63***). This was achieved via early flowering (r=+0.63***) and high percentage pod set (r=+0.54**) but no single attribute accounted for the differences in pods/m^2 between cultivars. Percentage pod set was greater in early-flowering cultivars but negatively correlated (r=-0.56**) with the potential sink size at each flowering node between cultivars indicating that high pod set is determined by more than one attribute. Seed yields were not simply related to cultivar maturity or to herbage yield at the end of flowering: therefore it may be possible to select for high herbage production and high seed yields together. Selection of cultivars in a wide range of environments may be one of the ways in which higher yielding cultivars over a wide range of seasons can be obtained.

In conclusion, the study shows that the reproductive potential of the annual medic seed crop is set by the number of flowers. The degree to which this potential is realised in terms of seed yield mainly depends on the proportion of the flowers that produce mature pods. The study shows that over 60% of the flowers fail to form mature pods. The physiological reasons for this could not be readily resolved in this experimental program as there is little information on the proportion of florets that are sterile, those that are fertile but are not successfully pollinated or fertilised, or those that become fertilised but abort. Agronomic studies in this thesis show that management strategies that maximise flower production and improve light penetration before the onset of severe soil moisture stress late in the season can improve pod set and seed yield. Management practices which restrict the amount of vegetative growth, such as strategic grazing/defoliation, or the use of low rates of herbicides, may increase seed yield. However, the success of these practices need to be modified to suit local environmental conditions and therefore need to be tested over a range of sites and seasons before more general recommendations can be made. The study also showed that high herbage production may not reduce the genetic potential to produce high seed yields and hence it is possible to select cultivars that have the ability to give both high herbage production and high seed yields.